DESIGN OF MODIFIED MICROWAVE POWER DIVIDER FOR RADAR ELECTRONIC WARFARE TRANSCEIVING SYSTEM

AMIR RUDIN BIN MAT DIN

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Faculty of Electrical Engineering

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Special dedicated to my beloved parents and friends

for their support and encouragement.

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ABSTRACT

Radar electronic warfare beam forming transceiving system requires robust components in order to fully utilize the radar functionality. One such essential component is the power divider and its complementary power combining circuitry. Conventional power divider operates at a fundamental frequency and odd harmonics. The thesis presents the design of a broadband modified 2-way microwave power divider with the capability of delivering an identical signal as the backup to a radar electronic warfare transceiving system. The chosen band of the radar system is from 0.7 GHz to 3 GHz. The design starts with the basic conventional 2-way Wilkinson power divider. Modifications were done in the form of having trisection transmission lines and integrate it with either single or combination of lumped element loads of resistor, capacitor and inductor. The component values were initially computed. Investigations on the configurations were performed using an electromagnetic simulation software. It can be concluded that an optimum broadband modified power divider has been successfully designed to operate between 0.7 GHz to 3 GHz with equal power division of -3 dB at each output port.

ABSTRAK

Sistem pemancar-penerima radar peperangan elektronik membentuk alur memerlukan komponen tahan lasak bagi memenuhi keperluan operasi radar. Satu komponen asas penting ialah litar pembahagi dan penggabung kuasa. Pembahagi kuasa lazim beroperasi pada frekuensi asas dan harmonik ganjil. Tesis ini membentangkan rekabentuk pembahagi kuasa gelombang mikro jalurluas dengan keupayaan menghasilkan isyarat serbasama sebagai isyarat kedua bagi sistem pemancar-penerima radar peperangan elektronik. Jalur operasi sistem radar ini dipilih bagi julat 0.7 GHz sehingga 3 GHz. Penyelidikan ke atas Rekabentuk litar dimulai dengan litar asas pembahagi kuasa 2-hala. Seterusnya, ubahsuaian dibuat terhadap litar dalam bentuk talian penghantaran tiga bahagian. Ini kemudiannya diintegrasi dengan beban tergumpal perintang, kapasitor dan induktor, tunggal atau gabungan. Nilai komponen dikira terlebih dahulu. Kajian menyeluruh terhadap prestasi rekabentuk dibuat menggunakan perisian simulasi elektromagnet. Dapat disimpulkan bahawa pembahagi kuasa yang optimum telah berjaya direka untuk berkendali antara 0.7 GHz dan 3 GHz. Ia mempunyai ciri pembahagian kuasa yang sama sebesar -3 dB pada setiap port keluaran.

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h	-	Thickness of Substrate
ε_r	-	Relative Permittivity
ε_e	-	Effective Permittivity
v_p	-	Phase Velocity
α	-	Attenuation Constant
β	-	Phase Constant
t	-	Thickness of Conductor
R	-	Resistance
G	-	Conductance
L	-	Inductance
C	-	Capacitance
Z_0	-	Characteristic Impedance
Z_L	-	Load Impedance
Γ	-	Reflection Coefficient

LIST OF ABBREVIATIONS

EW	Electronic Warfare
ELINT	Electronic Intelligence
WPD	Wilkinson Power Divider
MWO	Microwave Office
EM	Electromagnetic
BW	Bandwidth

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CHAPTER I

INTRODUCTION

1.1 Background of the Project

Power combiners and dividers are passive devices. These are needed in microwave systems for combining power of signals from several inputs and distributing the power of an input signal into several outputs, respectively. The combination can be at the front end, whereby it may be too laborious to design a high power amplifier. Instead, each output of the power divider can then be amplified, and all the amplified signals were then recombined. This will result in a highly amplified signal, with the amplification done using low power amplifiers.

One radar system being studied in this project is the Electronic Intelligence System or ELINT station [1]. It is a passive radar, functioning as a non-communication system. Its current operating capability is from 0.7 GHz to 18 GHz, with four antenna sectors, as illustrated in Figure 1.1. The bandwidth of the sectors is 0.7 GHz to 3 GHz, 3 GHz to 8 GHz and 8 GHz to 18 GHz, respectively. The 4^{th} sector is a dummy and can be upgraded.

The power divider is proposed to provide a back-up for the incoming signals. The station is part of an electronic warfare system available. A 2-way microwave power divider will ensures two identical signals of half the input signal be delivered

from the inception to the receiving circuitry. One signal will remain in operation. The second identical signal serves as the backup to the ELINT system. Wilkinson Power Divider (WPD) has been identified as the suitable configuration due to its simple circuitry. It also has excellent characteristics of excellent impedance matched at all ports, lossless, good isolation, compact, and can easily be fabricated using cost effective readily available materials. The narrowband property can be improved for broadband characteristics. The land mobile ELINT system is shown in Figure 1.2.

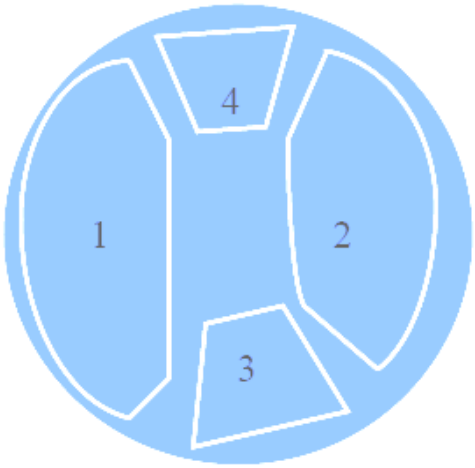

Figure 1.1 Antenna sectors of the ELINT System [1].

Figure 1.2 Land Mobile ELINT System [1].

1.2 Objective of the Project

The objective of this project is to design a modified power divider with the capability of delivering an identical signal as the backup to a radar electronic warfare transceiving system. It has to exhibit broadband characteristic within 0.7 GHz to 3 GHz. The bandwidth was chosen as it is the smallest range available.

1.3 Problem Statement

In recent years, the microwave technology has undergone tremendous development. One of such development is the Radar and Electronic Intelligence system known as the ELINT system. The ELINT system is a very expensive set-up in electronic warfare area. It is also a complex system. However, there is a limitation with regards to measurement and sampling aspects, due to the quality of the receiving signal. There is a crucial need for a backup system in the usage to enhance its capabilities. Hence, the proposed backup system in the form of a robust broadband microwave power divider can be used for monitoring and surveillance purposes. Accurate data can then be determined based on the quality of the pickup or received signal. The quality of the receiving signal can be significantly improved.

1.4 Scopes of Project

The scopes of the project are as follows:

(i) design of single basic WPDs, each operating at 0.9 GHz, 1.8 GHz and 2.7 GHz. These single frequencies will form the three initial main operating frequencies in the desired broadband region. Simulate [2] and investigate the possibility of improving the circuit characteristics. Simulations were done using electromagnetic simulation software, AWR Microwave Office 2004.

(ii) modification of the conventional WPD configuration into tri-sections of transmission lines to reflect the three identified main operating frequencies. Simulations are performed and the performances investigated.

(iii) further modifications using lumped element loadings.

(iv) fine-tune for optimum configuration which fulfill desired specifications.

The desired design specifications are as follows:

(i)	broadband operating frequencies	: 0.7 GHz to 3 GHz
(ii)	3 dB coupling or half-power division	: between ports 1 and 2, and ports 1 and 3
(iii)	good isolation of < -10 dB	: between ports 2 and 3
(iv)	good return loss of < -10 dB	: at ports 1, 2 and 3

The chosen microwave board has the following parameters:

(i)	PTFE microwave board	: RO4003 (Rogers)
(ii)	thickness of substrate , h	: 0.81 mm
(iii)	relative permittivity of substrate, ε_r	: 3.38
(iv)	loss tangent of substrate, tan δ	: 0.0027
(v)	thickness of conductor, t	: 35 μm

The basic single operation conventional WPD is shown in Figure 1.2 [3]. Two configurations available in the literature are used as the main references for this project [4], [5]. The corresponding circuits are shown in Figures 1.3 and 1.4, respectively.

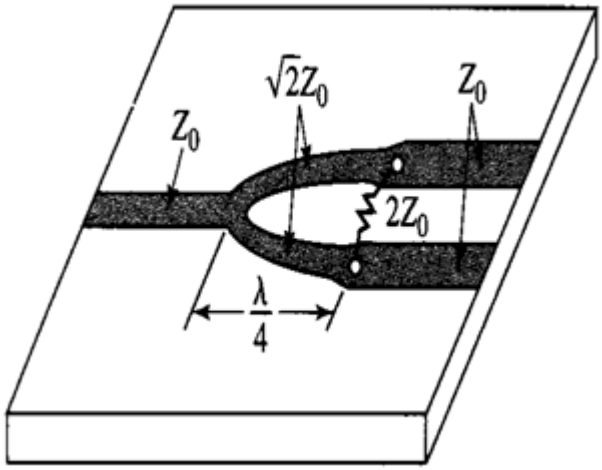

Figure 1.3 Conventional 2-way WPD [3].

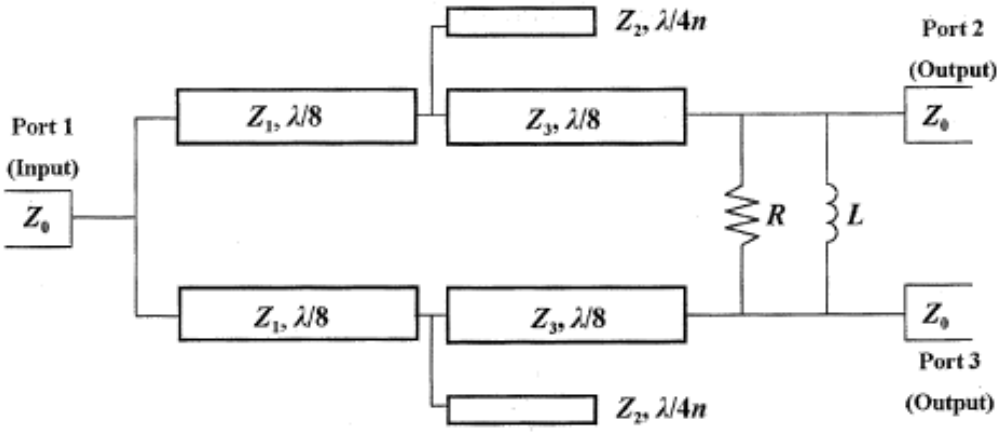

Figure 1.4 Dual-band WPD with open stub [4].

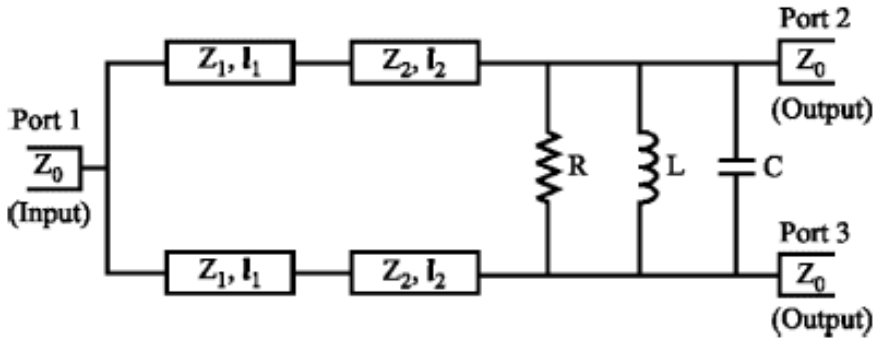

Figure 1.5 2 Way WPD with RLC [5].

1.5 Organization of Thesis

This thesis consists of five chapters. Chapter I present the objectives of the project, the problem statement, project background, the scope of project, and lastly the organization of this thesis.

Chapter II discusses the Power Divider theory, discussion include scattering parameter, odd and even analysis for Wilkinson Power Divider and its response, characteristic and design methodology.

Chapter III discusses on the software used in the design, mainly AWR Microwave Office 2004.

Chapter IV presents the results and discussions were made.

Chapter V concludes the thesis and suggestions for future work were made.

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